

**REMARKS**

Please reconsider the application in view of the following remarks. Applicant thanks the Examiner for carefully considering this application.

**I. Disposition of Claims**

Claims 1-5 are pending in this application. Claim 1 is independent. The remaining claims depend, directly or indirectly, from claim 1.

**II. Rejection under 35 U.S.C § 103**

Claims 1-5 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,876,602 ("Jons") in view of U.S. Patent No. 5,547,575 ("Demmer"). This rejection is respectfully traversed.

The claimed invention generally relates to a composite reverse osmosis membrane. As recited in claim 1, a reverse osmosis membrane in accordance with the invention includes a porous support and a polyamide skin layer formed on the porous support. The polyamide layer is formed by reacting an aromatic compound, which has at least two reactive amino groups, with a polyfunctional acid halide compound. Furthermore, the polyamide skin layer contains bromine.

Advantageously, a reverse osmosis membrane in accordance with the invention provides excellent desalination, water permeability, and ionic and non-ionic substance-separation performance. The non-ionic substances separated by such a membrane include nonelectrolyte organic compounds (e.g., isopropyl alcohol) and nondissociative substances (e.g., boron) at the pH range where composite reverse osmosis membranes are

normally used. As noted in the specification, conventional reverse osmosis membranes do not have sufficient rejections for nonelectrolyte organic compounds such as isopropyl alcohol (IPA). (Specification, p. 1, ll. 25-27). The ability to separate non-ionic compounds (e.g., IPA and boron) with high efficiency seems to depend on the presence of bromine on the polyamide skin layer. Thus, "when the polyamide skin layer has only chlorine, the rejection of nonelectrolyte organic compounds and general pH range nondissociative substances is not sufficiently improved." (See specification, p. 2, ll. 22-25) (emphasis added).

Jons teaches a reverse osmosis membrane including a polyamide layer with chlorine. Specifically, Jons teaches that "improved flux, lower salt passage and increased stability to base are obtained by treating the polyamide membrane, before use, with a chlorine containing solution." (Col. 2, ll. 34-37) (emphasis added). The membrane of Jons will not provide efficient separation of non-ionic compounds (e.g., IPA or boron) as disclosed in the present invention.

Jons further discloses that the treatment occurs under controlled conditions of high pH, temperature, time and concentration. Specifically, the objects of Jons invention "are accomplished when reverse osmosis composite membranes, comprising interfacially polymerized polyamides . . . are treated at a pH *above* 10.5 with 200 ppm to 10,000 ppm of a hypochlorite ion solution." (Col. 2, ll. 37-44). As taught by Jons, the properties of the membrane are related to the treatment conditions. Particularly, Jons teaches that the improved flux and lower salt passage are a result of the treatment at a pH above 10.5 using a hypochlorite ion ( $\text{ClO}^-$ ) solution of 200 ppm to 10,000 ppm. The high pH is required to have a high concentration of free  $\text{ClO}^-$  ion, which is in equilibrium with

HOCl. This equilibrium has a  $pK_a$  around 7.5. Thus, at pH above 10.5, the hypochlorite species is 100% in the form of  $ClO^-$ .

In contrast, a membrane in accordance with the claimed invention is treated with a free chlorine aqueous solution containing a bromine compound. (See, *e.g.*, specification, p. 3, ll. 36-37). Examples of the bromine compound include sodium bromide, potassium bromide, calcium bromide, magnesium bromide, etc. (Specification, p. 4, ll. 16-21). The free chlorine aqueous solution preferably has a low free chlorine concentration of 1 to 100 ppm (mg/l). (Specification, p. 4, ll. 1-7). The pH of the free chlorine aqueous solution is preferably in the range from 4 to 6.8, which favors the formation of HOCl instead of  $ClO^-$ . (Specification, p. 4, ll. 29-30). The Applicant believes that HOCl, but not  $ClO^-$ , oxidizes the bromine compound to HOBr or its equivalent, which then brominates the aromatic polyamide membranes. Thus, the conditions use to produce membranes of the present invention are very different from those used by Jons. Consequently, the resulting membranes are expected to have different properties.

Demmer teaches a method for grafting a second polymer layer on a pre-formed polymer object, while avoiding grafting in the interior of the formed body polymer. (Col. 2, ll. 15-19). According to Demmer, a method of grafting is characterized in that "the hydrogen atoms located on the nitrogen are replaced by halogen before the grafting, preferably by chlorine or bromine, and that the grafting is carried out in the presence of at least one ethylenically unsaturated monomer and of a reducing agent. The grafting is therefore initiated by radical formation on the nitrogen." (Col. 5, ll. 17-23). Demmer's method converts the amides into the N-halogen derivatives, which then decompose to provide radicals for the grafting reactions. Halogen compounds having a +1 valance

(e.g., chloramines T) are suitable for generating the N-halogen derivatives. (Col. 7, l. 64 – Col. 8, l. 4). After grafting the second polymer layer on the first polymer form body, the halogen atoms will not end up in the final products. That is, Demmer concerns the formation of reactive N-halogenated amide intermediates, not the formation of stable halogenated final products. Thus, there is no motivation for one of ordinary skill in the art to combine Jons and Demmer.

Furthermore, although Demmer refers to microporous membranes (MF) and ultrafiltration membranes (UF) as possible formed body on which the second polymer layer can be grafted, the MF and UF membranes are distinctly different from the reverse osmosis (RO) membranes. MF and UF membranes have relatively large pores and are used for the removal of large molecules, e.g., those with molecular weights from 5,000 to 1,000,000 daltons. (See, e.g., Col. 2, ll. 59-61). In contrast, the RO membranes of the invention remove substances of much smaller molecular weights, for example, isopropyl alcohol having a molecular weight of 60 daltons.

The Examiner asserts that “[i]t would have been obvious to one skilled in the art at the time the invention was made to substitute the hypochlorite treatment of Jones [sic], for the composite polyamide membrane, with a hypobromite treatment, since hypobromite and hypochlorite are art well recognized equivalents, as evidenced by Demmer.” (Action, p. 3). Due to the unpredictable nature of the chemical art, this assertion cannot be generalized in every area. In fact, the Applicant has found that while bromination of polyamide membranes provides efficient separation of non-ionic materials (e.g., IPA or boron), chlorination does not. (See, e.g., specification, p. 2, ll. 22-25).

Assuming *arguendo* that hypobromite, as taught by Demmer, is used to substitute for hypochlorite in the Jons reaction, it still will not produce the RO membranes of the present invention. Jons teaches that reaction conditions impact the properties of the resulting membranes. The pH and concentrations of hypochlorite used by Jons are very different from the pH and concentrations of the free chlorine aqueous solution of the present invention. Therefore, the membranes of the present invention are expected to be distinct from the membranes of Jons.

For the reasons stated above, claim 1 is patentable over Jons and Demmer, whether considered separately or in combination. Claims 2-5 depend from claim 1 and, therefore, are allowable for at least the same reasons. Accordingly, withdrawal of this rejection is respectfully requested.


### **III. Concluding Remarks**

Applicant believes this reply to be fully responsive to all outstanding issues and place this application in condition for allowance. If this belief is incorrect, or other issues arise, do not hesitate to contact the undersigned or his associates at the telephone number listed below. Please apply any charges not covered, or any credits, to Deposit Account 50-0591 (Reference Number 04558.044001).

Respectfully submitted,

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